

Automated Analysis of dUT1 from IVS Intensive Sessions with VieVS

Minttu Uunila ¹, Rüdiger Haas ², Niko Kareinen ¹, Timo Lindfors ¹

¹⁾ *Aalto University Metsähovi Radio Observatory*

²⁾ *Chalmers University of Technology, Onsala Space Observatory*

Contact author: Minttu Uunila, e-mail: minttu.uunila@aalto.fi

Abstract

The Vienna VLBI Software (VieVS) version 1d is used in its batch mode to analyze IVS Intensive sessions automatically to derive the Earth rotation parameter dUT1. The automation process uses a shell script that is run daily by a cron process. The goal is to achieve dUT1 results as soon as the NGS file is fetched from the VieVS server. Three types of analysis strategies, called S-1, S-2 and S-3, are used in the process in order to compare different parameterizations and to improve the latency of deriving dUT1. The S-1 analysis strategy uses as a priori Earth orientation parameters the values provided by the EOP-file “finals2000A”, uses as mapping function the Global Mapping Function (GMF), and does not apply atmospheric loading. The S-2 analysis strategy differs from the first analysis strategy by using the Vienna Mapping function (VM1) instead of the GMF and by applying atmospheric loading. The S-3 analysis strategy differs from the second approach by using the IERS C04 values as a priori Earth orientation parameters. All other parameters are treated identically for the three analysis strategies. The latency of the results for the first analysis strategy is 2-3 days from the end of a session and is dominated by the time that is necessary to correlate the observational data and to pre-process the data, i.e. to provide an NGS file where group delay ambiguities are resolved and the ionospheric effects are corrected. The latency of the results for the second strategy is slightly worse, about 3-4 days, mainly due to the time that it takes until VMF1 and atmospheric loading based on ECMWF analysis data are available. The latency of the results for the third strategy is even worse, about 30 days, and is dominated by the time that it takes until the IERS C04 data are available. The RMS values of the formal errors of the three strategies in the case of INT1 sessions are 21, 22, and 17 microseconds for strategies 1, 2 and 3, respectively. The formal error of S-3 is the best, but the latency is the worst. To enhance the latency of the S-1, we currently are working on including the necessary pre-processing steps, i.e. group delay ambiguity resolution and ionospheric correction, directly into VieVS. The results of the automated analysis are provided both as data files and in graphical form on the Metsähovi Web pages http://www.metsahovi.fi/vlbi/vievs/results_GMF, [.../results_VM1](http://www.metsahovi.fi/vlbi/vievs/results_VM1), and [.../results_C04](http://www.metsahovi.fi/vlbi/vievs/results_C04), respectively.

1. Introduction

The Vienna VLBI Software (VieVS [1]) version 1d is used in its batch mode to analyze IVS Intensive sessions automatically in order to derive the Earth rotation parameter dUT1. INT1 and INT2 baselines are displayed in Figure 1. The automation process uses a shell script that is run daily by a cron process. The goal is to achieve dUT1 results as soon as the observed delays are available as an NGS file. Three types of analysis strategies (S-1, S-2, and S-3) are used in the process in order to compare different modeling options. The different modeling options used for the different strategies are listed in Table 1. All other models are identical for the S-1, S-2, and S-3, see Table 2.

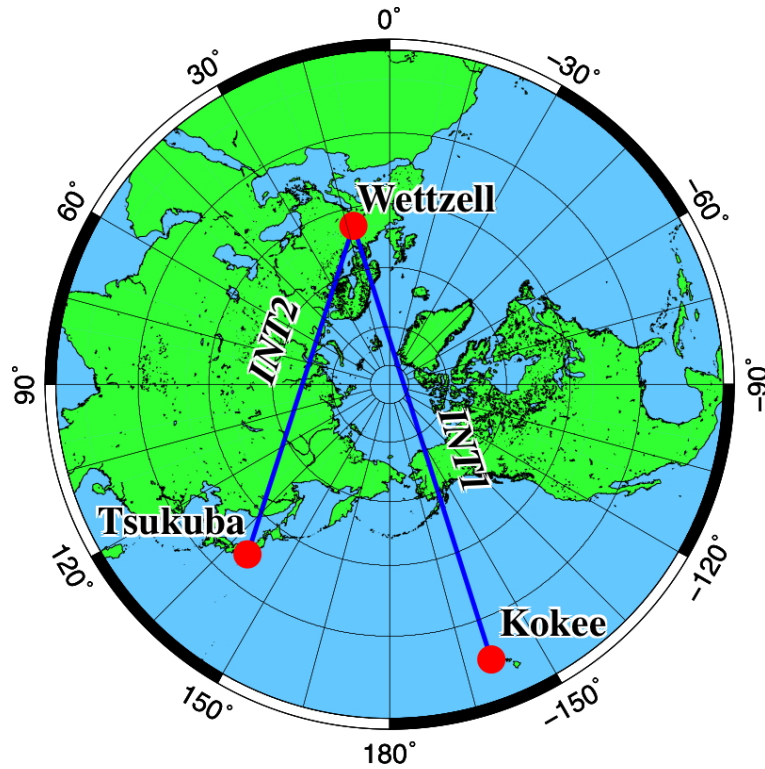


Figure 1. The baselines used for the INT1 and INT2 sessions.

Table 1. Modelling options for strategies S-1, S-2, and S-3.

Strategy	S-1	S-2	S-3
A priori EOP	USNO finals2000A	USNO finals2000A	IERS C04
Mapping function	GMF	VM1	VM1
Atm. loading	no	yes	yes

Table 2. Other models used.

TRF	VTRF2008
CRF	ICRF2
Ephemerides	JPL421
Precession/nutation	IAU 2000A
Elevation cutoff	no elevation cutoff used
Hf EOP	IERS conv. 2003
Ocean loading	FES2004

2. Latency of the Results

The latency of the results for the S-1 is 2-3 days from the end of a session, and it is dominated by the time that is necessary to correlate the observational data and to pre-process the data, i.e.

to provide an NGS file where group delay ambiguities are resolved and the ionospheric effects are corrected. The latency of the results for the S-2 is slightly worse, about 3-4 days, mainly due to the time that it takes until VMF1 and atmospheric loading based on ECMWF analysis data are available. The latency of the results for the S-3 is even worse, 30 days, and is dominated by the time that it takes until the IERS C04 data are available.

3. Results

Table 3 presents the RMS values of the corrections with respect to the used a priori dUT1 values and the average values of the formal errors for the three analysis strategies. As the latency becomes worse, the variation of the dUT1 gets smaller. In order to improve the latency of strategy S-1 we currently are working on including the necessary pre-processing steps, i.e. group delay ambiguity resolution and ionospheric corrections, directly into VieVS.

Table 3. Impact of the three different analysis strategies S-1, S-2, and S-3 on the dUT1 estimates for both INT1 and INT2 sessions: average formal errors of the dUT1 estimates and RMS agreement of the dUT1 estimates with respect to IERS C04 dUT1 values.

	Strategy		
	S-1	S-2	S-3
INT1			
average formal error (μ s)	16.49	16.48	14.77
RMS w.r.t. IERS C04 (μ s)	261.77	205.87	50.15
INT2			
average formal error (μ s)	61.89	61.73	62.00
RMS w.r.t. IERS C04 (μ s)	865.40	843.07	743.38

Figures 2 and 3 depict the dUT1 results for both INT1 and INT2 sessions using the three different strategies. Strategies S-1 and S-2 use a priori Earth orientation parameters (EOP) from USNO finals2000A. Usually, these values are predicted EOP, resulting in the results shown with red dots. In case of additional delays, e.g. late availability of NGS files, the USNO finals2000A has been updated already by final EOP. Results obtained using these a prioris are shown with green dots.

The results of the automated analysis are provided both as data files and in graphical form on the Metsähovi Radio Observatory Web pages:

```
http://www.metsahovi.fi/vlbi/vievs/results_GMF
                               /results_VM1
                               /results_C04
                               /latest_dut1_S-1+S-2+S-3_XK.png
                               /latest_dut1_S-1+S-2+S-3_XU.png
```

RMS values of the INT1 and INT2 sessions for all three analysis strategies are provided at:

```
http://www.metsahovi.fi/vlbi/vievs/latest_RMS+WRMS.txt
```

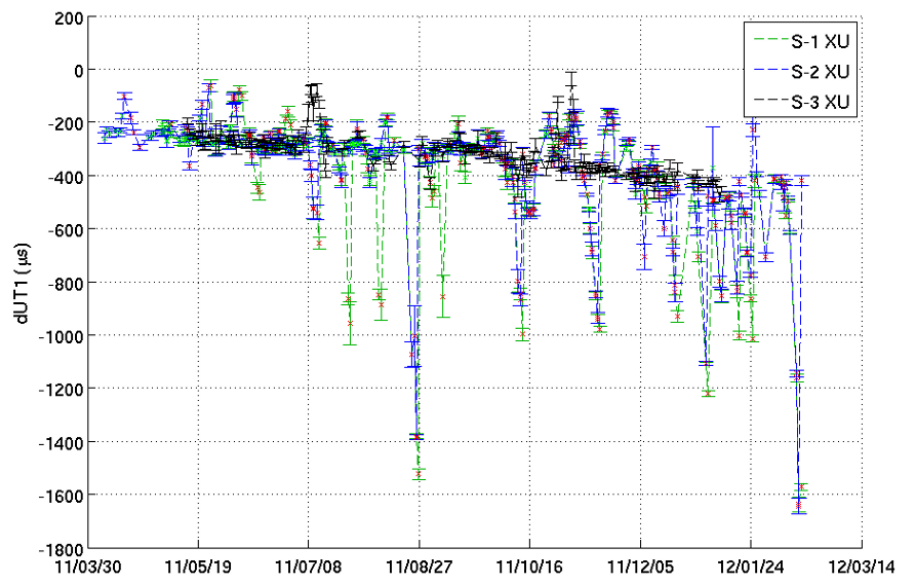


Figure 2. dUT1 from INT1 using strategies S-1, S-2, and S-3. Red and green dots indicate that the a priori EOP from USNO finals2000A were either predicted EOP (red) or final EOP (green).

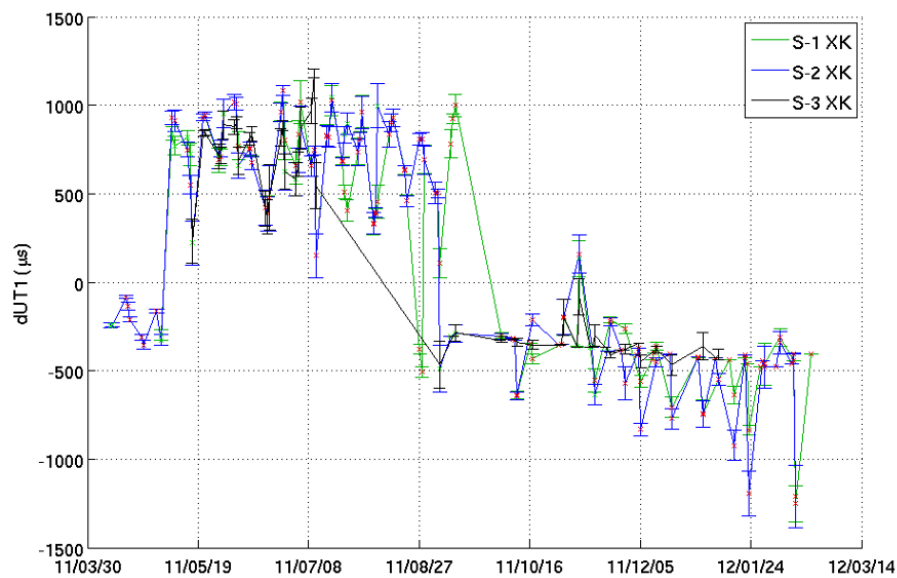


Figure 3. dUT1 from INT2 using strategies S-1, S-2, and S-3. Red and green dots indicate that the a priori EOP from USNO finals2000A were either predicted EOP (red) or final EOP (green).

4. Conclusions

Figure 2 depicts large variations for the dUT1 results when predicted EOPs are used in the analyses (see S-1 and S-2). This variation is not visible when final EOP values are used as a priori values in the analysis (S-3). The jump in Figure 3 can be explained by the Tohoku earthquake that affected the Tsukuba station. Accurate coordinates for Tsukuba were not available for the period March-September 2011, thus causing a jump in dUT1. This also causes the RMS values of the corrections with respect to the used a priori dUT1 to be large for the INT2 series. More data, especially using analysis strategy S-3, are needed to be able to compare the INT1 and INT2 dUT1 results. From the INT1 results, it can be seen that S-1 gives the largest formal error average value (16.48 microseconds), and S-3 the smallest (14.77 microseconds). The RMS value of the corrections to the dUT1 a priori values is smallest with S-3, and largest with S-1.

In the future a script could be implemented to also analyze IVS 24-h sessions automatically. In this case the ambiguity resolution and ionospheric correction step needs to be automated already in VieVS.

Acknowledgements

The Metsähovi team acknowledges support from the Academy of Finland (grant number 135101).

References

- [1] Böhm, J, S. Böhm, T. Nilsson, A. Pany, L. Plank, H. Spicakova, K. Teke, H. Schuh. The new Vienna VLBI Software VieVS, in Proceedings of IAG Scientific Assembly 2009, In: International Association of Geodesy Symposia Series Vol. 136, edited by S. Kenyon, M. C. Pacino, and U. Marti, pp 1007-1011, 2012, doi: 10.1007/978-3-642-20338-1_126.